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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04N 1/19, G06K 1/28, 9/78	A1	(11) International Publication Number: WO 98/38792 (43) International Publication Date: 3 September 1998 (03.09.98)

(21) International Application Number: PCT/US98/03989

(22) International Filing Date: 27 February 1998 (27.02.98)

(30) Priority Data:
60/038,547 28 February 1997 (28.02.97) US

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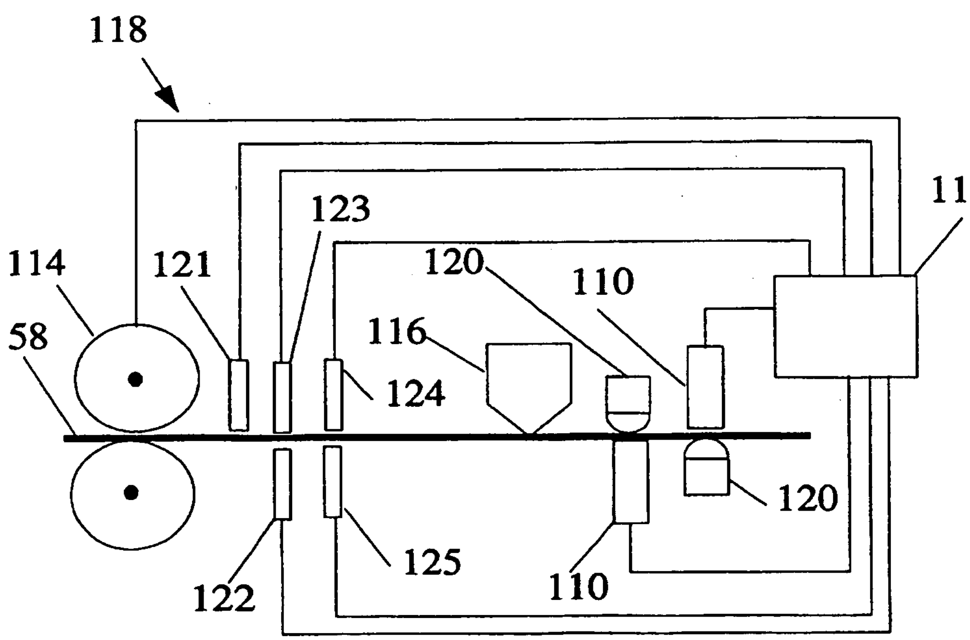
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: MAGNETORESISTIVE SCANNING SYSTEM



(57) Abstract

A magnetoresistive scanning array (110) and system (118) are provided for scanning magnetic fields on an area of an object (58). The sensor array (110) comprises a plurality of independent magnetoresistive sensors held in a predetermined configuration. Several sensor array configurations are disclosed that are capable of generating two–dimensional data of the magnetic fields on an object. The system further comprises a processor device that is capable of analyzing and manipulating the data and performing other functions related to the system. Applications for the present invention include currency validation, document scanning, and read only memory devices.

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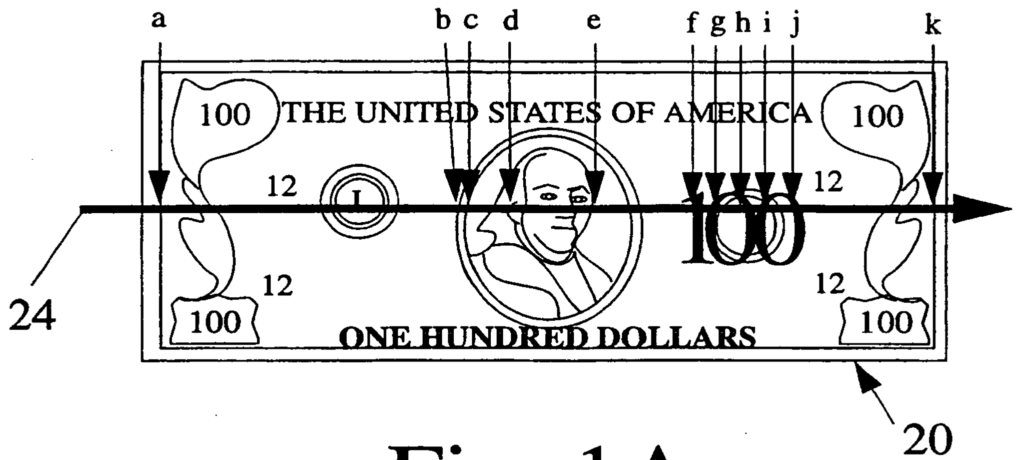
a
b c d
e
f g h i j
k
100
THE UNITED STATES OF AMERICA
100
12
12
100
12
12
100
100
ONE HUNDRED DOLLARS
24
20

Fig. 1A

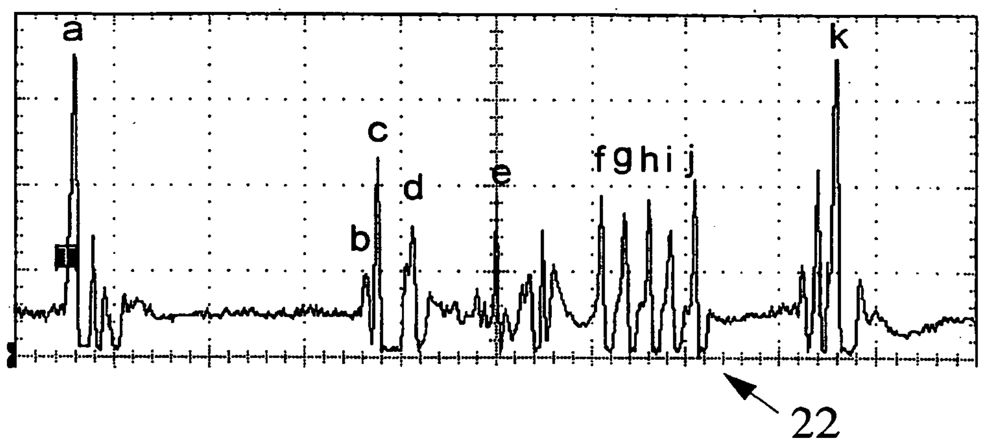
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Fig. 1B

system.

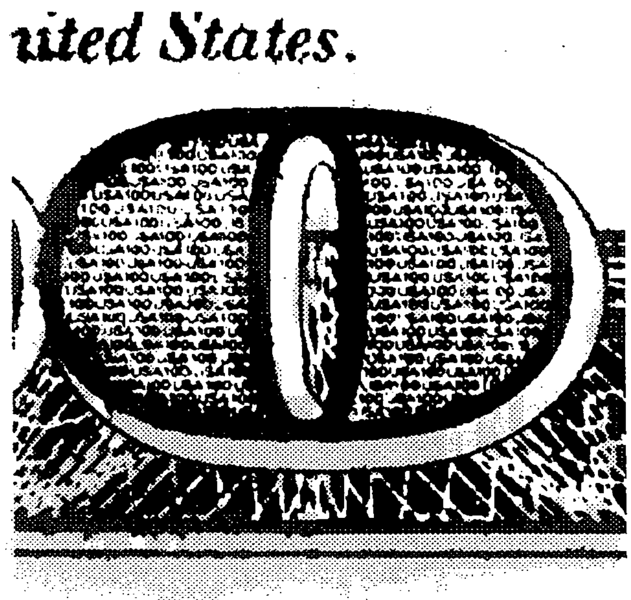

Fig. 2A

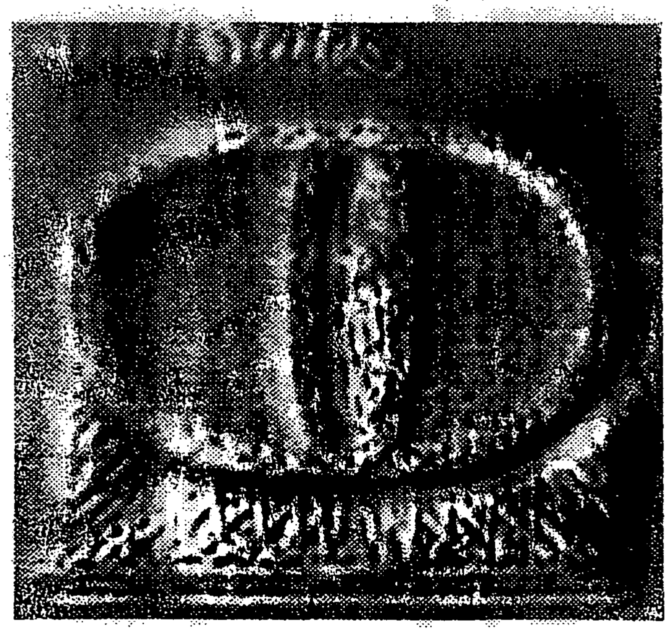

Fig. 2B

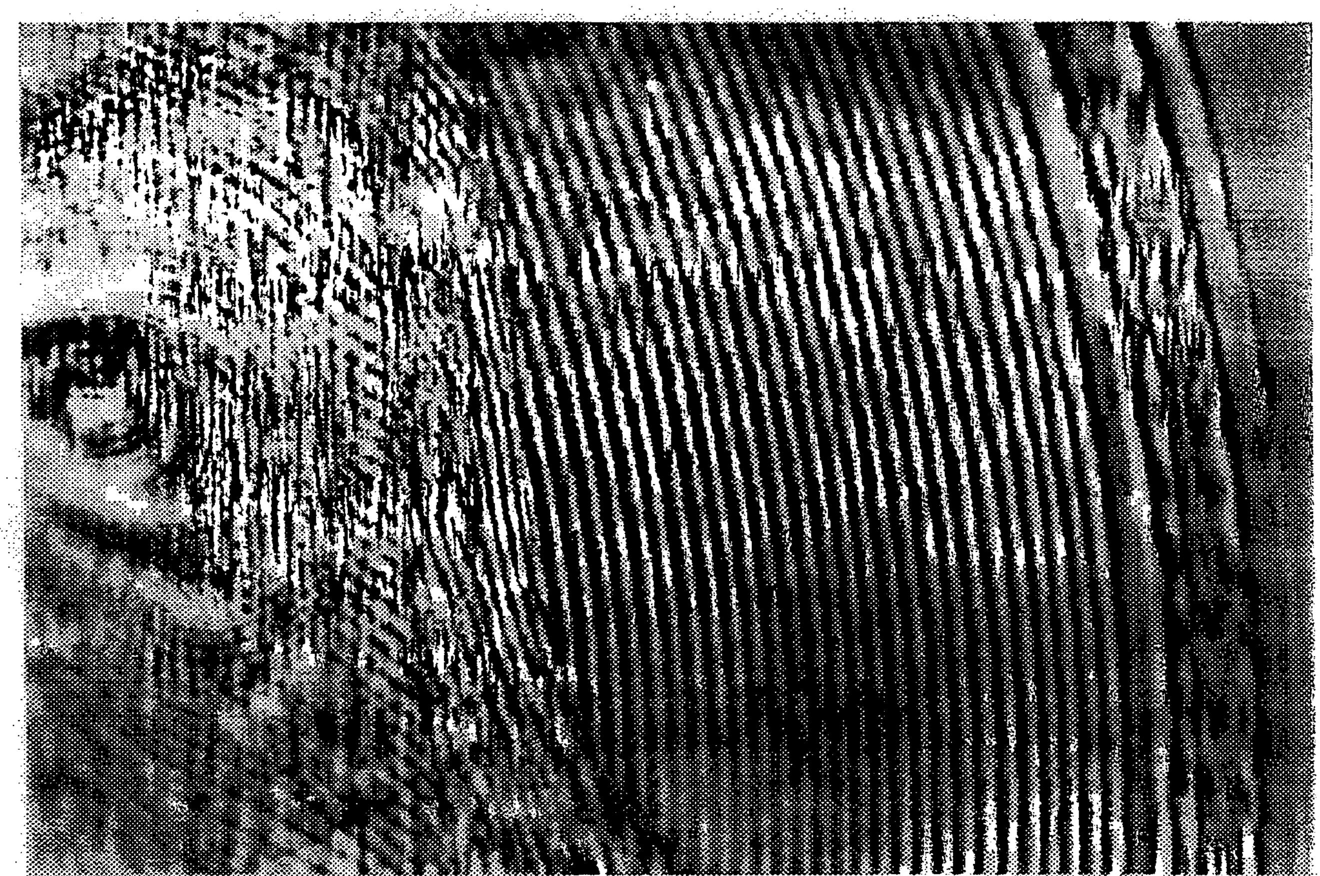

Fig. 2C

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MAGNETORESISTIVE SCANNING SYSTEM

CROSS REFERENCES TO RELATED APPLICATIONS

This application claims priority of U.S. provisional patent application serial No. 60/038,547 filed on February 28, 1997.

BACKGROUND OF THE INVENTION

1. Field of Invention

This invention relates to an array and system for scanning and analyzing magnetic fields. More particularly, this invention relates to an array and system that is capable of scanning magnetic fields in two-dimensional areas, generating two-dimensional data, generating two dimensional images of the magnetic fields, and analyzing the data.

2. Description of Related Art

Magnetoresistive sensors are well known in the art for measuring or detecting magnetic fields. These sensors utilize materials in which internal electrical resistance changes in response to changes in applied magnetic fields. The output signals produced by magnetoresistive sensors may be proportional to the intensity of the applied magnetic fields.

Magnetoresistive sensors have been adapted for use in a variety of applications. For example, U.S. patent number 5,378,85,2 to Jones Jr. et al. discloses a device that is intended for use with currency validation equipment. U.S. currency and other currencies utilize magnetic ink to produce a distinctive magnetic signature. Figures 1A and 1B illustrate the operation of a prior art one-dimensional magnetoresistive sensor, such as the sensor disclosed in Jones Jr. et al., in currency validation. As the sensor moves across a bill 20 on a line 24, it

produces an output signal that is proportional to magnetic fields on the bill. The output signal may be plotted to obtain a magnetic curve 22 in which spikes a-k correspond to magnetic ink lines a-k on bill 20. Curve 22 may then be compared to a standard curve to determine the validity of bill 20.

Prior art magnetoresistive devices, however, have failed to provide sensors and systems that are capable of efficiently scanning two-dimensional areas and producing high resolution two-dimensional data of magnetic fields. Although a one-dimensional line of data across an object renders useful information, a much greater amount of information can be obtained from two-dimensional data. In the field of currency validation, for example, a two-dimensional "magnetic image" can be generated for verifying the authenticity of a bill. Figure 2A is an optical image of a zero on a 1997 U.S. $100 bill taken with a charge coupled device camera with a magnification system. Figure 2B is a two-dimensional magnetic image of the zero in Figure 2A that may be produced by the present invention. Figure 2C is a two-dimensional magnetic image of a portion of the portrait of a U.S. $100 bill. As can be seen from Figures 2B and 2C, two-dimensional magnetic images are capable of generating optical quality images. Although it is difficult for counterfeiters to reproduce a one-dimensional magnetic curve of a bill (as seen in Figure 1A), it is much more difficult to reproduce intricate two-dimensional magnetic patterns. One-dimensional scanning systems are also more sensitive to variations in printing, migration of magnetic material over time, and the positioning of bills in the scanning system.

Two-dimensional magnetoresistive scanning systems may also be utilized in other applications. For example, many computer printers utilize or can be adapted to utilize magnetic toner. When the toner is deposited on a printed page, the letters and figures on the page are capable of producing a magnetic image. Two-dimensional magnetoresistive

scanning systems may be used to efficiently scan the letters and figures on the page to generate accurate two-dimensional data. Well known character and pattern recognition techniques may then be used to analyze and manipulate the data.

A magnetoresistive scanning system can also be used to store and read data. Data can be stored on an object by depositing magnetic material on the object in a predetermined pattern and in predetermined densities. A scanning system can then read the data from the object by detecting the location and intensities of the magnetic fields of the magnetic material. Data stored in this way is more secure than other magnetic storage devices. For example, disk drives and tape cassettes are vulnerable to strong magnetic fields that can erase data stored on these devices. Since magnetoresistive scanning systems only rely upon the location and densities of magnetic material, not polarity of magnetic fields, the data is not vulnerable to strong magnetic fields. Thus, inexpensive media, such as paper or plastic, may be used as permanent read only memory.

In many applications magnetoresistive scanners offer significant advantages. Magnetoresistive scanners tend to be highly robust and durable. Unlike optical scanners, magnetoresistive scanners are not subject to contamination from dust, oils, and other substances. Magnetoresistive scanners also do not sense extraneous marks or optical impurities that may be present on an object. Thus, magnetoresistive scanners can produce more accurate data under many circumstances.

However, prior art magnetoresistive sensors cannot be efficiently used for two-dimensional applications. For example, the device disclosed in Jones, Jr. et al. utilizes a four sensor design that is intended to enhance the output signals of the device. However, the sensors are positioned in line with the direction of motion of the sensors relative to a bill; thus, they are not capable of scanning a two dimensional area during a single movement

relative to a bill.

U.S. patent number 4,98,850 to Masuda et al. discloses a device that is intended for use with magnetic media readers. The device utilizes a magnetoresistive element array with discrete and widely separated magnetoresistive elements. Unlike Jones, Jr. et al., the elements are positioned in a parallel arrangement with respect to the direction of motion of the magnetic media relative to the array. However, this device is intended to read separate, discrete rows or lines of data from a magnetic card. The array is not intended to scan an area and generate two-dimensional data capable of representing the magnetic fields in that area. The distance between the sensors is at least twice the width of a sensor; therefore, a continuous area could not be scanned during a single pass over a two-dimensional area.

Other devices have been developed for producing two-dimensional magnetic data. The devices disclosed in U.S. patent numbers 3,978,450 to Sanner et al. and 4,058,706 to Kao et al., for example, disclose read heads with a plurality of sensor elements. The elements are arranged in two or more parallel arrays that are perpendicular to the direction of movement over an object. The references are silent as to the type of sensor elements used. However, the most likely reason why the devices use multiple parallel arrays of sensors instead of a simpler single array is because they utilize inductive sensors. Unlike magnetoresistive sensors, inductive sensors cannot be placed close to each other because of interference, cross coupling, and other problems. To overcome these limitations both Sanner et al. and Kao et al. utilize multiple parallel arrays of inductive sensors. The sensors in each array are widely spaced and it is necessary to use a complex circuit to combine the signals of the arrays to obtain two-dimensional data during a single sweep. Neither Sanner et al. nor Kao et al. suggests the use of magnetoresistive sensors.

fields on an object.

These and other objects of the present invention may be realized by reference to the remaining portions of the specification, claims, and abstract.

2. Brief Description of the Invention

The present invention comprises a magnetoresistive sensor array. The sensor array comprises at least one substrate and a plurality of magnetoresistive sensors. Both the substrate and sensors are formed by methods that are well known in the art. In the preferred embodiment, the sensors are very small providing a high linear density with small distances between the sensors. This provides high resolution which is necessary in many applications, such as currency validation.

The sensor array may be designed in many different configurations. One configuration provides pairs of magnetoresistive sensors in a differential configuration. The differential configuration provides for the cancellation of ambient magnetic fields. The present invention may also include a flux guide for directing magnetic fields to a sensor. The sensor array may also comprise amplifying and multiplexing circuitry for conditioning the output signals of each sensor. The amplifying and multiplexing circuit may receive impute signals from a processor or other associated device.

The present invention also comprises a magnetoresistive scanning system for scanning data from an object. The scanning system comprises at least one magnetoresistive sensor array, at least one magnet, and a processor. The magnet is provided for magnetizing magnetic material on the object before it is scanned by the array. The processor is adapted to control the scanning system and analyze data obtained from the object. Analysis of the data

SUMMARY OF INVENTION

1. Objects of the Invention

It is an object of the present invention to provide a magnetoresistive sensor array capable of scanning magnetic fields on an object.

It is another object of the present invention to provide a magnetoresistive sensor array with differential pairs of magnetoresistive elements for reducing noise caused by ambient magnetic fields.

It is a further object of the present invention to provide a magnetoresistive sensor array in which the sensors are formed using integrated circuit manufacturing techniques to provide a high-density array.

It is a further object of the present invention to provide a magnetoresistive scanning system in which a sensor array provides data to a processor for performing various functions.

It is a further object of the present invention to provide a magnetoresistive scanning system that is capable of authenticating currencies based on the magnetic material in the currencies.

It is a further object of the present invention to provide a magnetoresistive scanning system that is capable of generating two-dimensional images of magnetic fields on an object.

It is another object of the present invention to provide a nonvolatile read only memory in which the two dimensional location of magnetic fields on an object is used to convey information.

It is a further object of the present invention to provide a magnetoresistive scanning system in which the scanning system may read data and programs by scanning magnetic

may include many methods that are well known in the art, such as character and pattern recognition. The processor may also communicate with other devices for performing various functions related to the scanning system.

One embodiment of the present invention is to provide a currency validation system for verifying the authenticity of a currency object. The currency object may be a bill, banknote, certificate, license, title, checks, or any other document that is capable of holding magnetic material. The currency object is introduced into the system of the present invention and the sensor array scans data from the object. The processor then analyzes the data, comparing it to a template or set of acceptable parameters. The system is also capable of generating a high resolution image of the magnetic fields of the object and presenting this image to users of the system.

The above description sets forth, rather broadly, the more important features of the present invention so that the detailed description of the preferred embodiment which follows may be better understood, and contributions of the present invention to the art may be better appreciated. There are, of course, additional features of the invention that will be described below and which will form the subject matter of claims. In this respect, before explaining at least one preferred embodiment of the invention in detail, it is to be understood that the invention is not limited in its application to the details of the construction and to the arrangement of the components set forth in the following description or as illustrated in the drawings. The invention is capable of other embodiments and of being practiced and carried out in various ways. Also, it is to be understood that the phraseology and terminology employed herein are for the purpose of description and should not be regarded as limiting.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1A is substantially a schematic representation of a magnetic material bearing $100 bill with a scanning path of a prior art one-dimensional magnetoresistive sensor indicated thereon.

Figure 1B is substantially a magnetic curve of the bill shown in Figure 1A of a type that may be produced by a prior art sensor.

Figure 2A is a magnified optical image of a zero from a 1997 U.S. $100.00 bill.

Figure 2B is substantially a two-dimensional magnetic image of the zero shown in Figure 2A that may be produced by the present invention.

Figure 3 is substantially a top schematic view of one embodiment of the sensor array of the present invention.

Figure 4A is substantially a front schematic view of another embodiment of the sensor array of the present invention that utilizes differential sensors and a permanent magnet.

Figure 4B is substantially a cross sectional schematic view of the embodiment in Figure 4A taken along line I-I.

Figure 4C is substantially an isometric schematic view of a differential sensor configuration of the embodiment shown in Figure 4A.

Figure 5 is substantially a cross sectional schematic view of an another sensor array of the present invention that utilizes a flux guide.

Figure 6 is substantially a schematic view of a multiplexing circuit in use with a sensor array of the present invention.

Figure 7 is substantially a side schematic view of a scanning system of the present invention.

Figure 8 is substantially a block schematic diagram of a scanning system of the

present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As seen in Figure 3, the present invention comprises a magnetoresistive sensor array generally indicated by reference number 30. Sensor array 30 comprises a plurality of magnetoresistive sensors 32 attached to a substrate 34. Sensors 32 and substrate 34 are shown in simple block form for purposes of illustration; many shapes and configurations may be utilized. Sensor array 30 also comprises conductive input connectors 36 for supplying electrical current to each sensor 32 and output connectors 38 for transmitting output signals to processing circuits.

In the preferred embodiment, sensors 32 and substrate 34 are formed using techniques that are well known in integrated circuit and sensor manufacturing technology. The individual magnetoresistive sensors 32 may comprise several layers that are deposited either by vacuum vapor depositions, epitaxy, metalorganic vapor deposition, or sputtering, to name a few. These films may comprise the actual magnetoresistive film, which may be NiFe or FeCo, an electrical, nonmagnetic insulating layer, and a magnetically soft alloy, flux guide layer. A magnetically hard layer may be deposited (which is essential a permanent magnet) to bias the magnetoresistive film. Bias may be needed to bring the output signal of the magnetoresistive film into a linear range. Electrical connectors 36 and 38 may be made out of copper or aluminum. The layers may be deposited on substrate 34, which may comprise ceramic material, after masks have been consecutively placed on the substrate by photolithography. Additional shielding layers may be deposited to limit the sensitivity of the

magnetoresistive film to a small region.

Many different sensor designs are possible with these manufacturing techniques. For example, it is possible to produce sensors that utilize the Giant Magnetoresistive Effect and the Colossal Magnetroresistive Effect.

Once sensors 32 are deposited on substrate 34, the substrate is cut by a stylus and functional groups are assembled on a second substrate, which could be made of other material. Once the array is attached to a supporting structure, wire bonds are made that connect power to individual groups of sensors. The finished assembly can be tested for proper function and faulty connections may be corrected if necessary. The assembly may then be inserted into a plastic molded object and embedded with an epoxy. After the epoxy is cured, the device may undergo a final functionality test.

These and other manufacturing techniques now make it practical to form high-density magnetoresistive sensor arrays with very small sensors and small sensor separations. Similar techniques have been used to produce complex optical sensors that may be placed on a single microchip. Sensors 32 may be placed on substrate 34 in sufficient densities to achieve high resolution desired in many applications. For example, in bill validation and character recognition, the linear density of sensors 32 is preferably at least one sensor per millimeter. Densities of this magnitude are not possible with prior art sensor arrays, such as the one found in Masuda et al. In order to achieve high resolution it is also desirable to minimize the distance between sensors. In bill validation and character recognition, the distance between sensors is preferably less than ten microns. Small sensor separations such as this cannot be used with prior art inductive sensors because of interference, cross coupling, and other problems associated with these sensors.

Sensor array 30 may be any length required to meet the needs of a particular

application. In bill validation applications, sensor array 30 is substantially the width of a bill. However, the cost or difficulty of manufacturing long sensor arrays may require the use of multiple sensor arrays or substrates of shorter lengths. It is recognized that the sensor array of the present invention may take many different configurations. For example, the array need not be placed in line or on a single plane. Furthermore, the structure of the individual sensors need not be the same throughout an array. Smaller sensors may be used in some portions of the array to achieve finer resolution and flux guides may be used in some or all sensors to direct magnetic fields.

The resolution of array 30 is defined as the ability of the array to distinguish between closely spaced small areas of magnetic ink on an object in both the x and y directions. The resolution in the direction of scan depends on the width of the sensor 32 the width of the flux guide used to direct the field to the sensing element, and the sampling rate. Decreasing the width will increase the resolution in this direction. The resolution of the array, Δy, in the direction perpendicular to the scan depends on the length of sensor 32 as well as the distance between sensors. Decreasing length and separation enhances resolution.

Figure 4A and 4B disclose an alternative sensor array configuration 50 in which pairs of sensors are used in a differential configuration. Upper sensors 52 and lower sensors 54 are attached to substrate 56 in a substantially parallel arrangement separated by the height of the substrate. A permanent magnet or electromagnet 60 may be provided in close relative proximity to sensors 52 and 54 for biasing the sensors and for magnetizing the magnetic field bearing substances on object 58. The entire array may be encased in a protective cover 62.

The differential configuration allows for the reduction of noise caused by ambient magnetic fields. Lower sensors 54 sense magnetic fields from object 58. However, in this embodiment the additional distance from the object of upper sensors 52 substantially weakens

the magnetic fields from the object. As seen in Figure 4C, a differential circuit is used in the differential configuration to produce an output signal for each sensor pair. A common input voltage 64 is provided for upper elements 52, a common ground is provided for lower sensors 54, and an output connector 68 is provided for each pair of sensors.

As seen in Figure 5, the present invention comprises a sensor array 70 that is adapted to use a flux guide 72 for directing magnetic flux onto sensors 74 and 76. Magnetic flux guides are well known in the art and many different configurations may be used to achieve the objects of the present invention. In the preferred embodiment, flux guide 72 and sensors 74 and 76 are integrally formed on substrate 78 using integrated circuit manufacturing techniques. Sensors 74 and 76 are provided in a differential configuration to provide a differential output signal.

Figure 6 discloses an amplifying and/or multiplexing circuit that may be used with the sensor arrays of the present invention. Sensor array 90 comprises a plurality of sensors 92. In the example disclosed in Figure 6, differential sensor pairs are used to produce differential output signals; however, a non-differential configuration may also be used. Each sensor pair has an output connection 94 for transmitting output signals to amplifying and multiplexing circuit 96. The circuit 96 amplifies sensor output signals and multiplexes the signals for transmission to a processor. Circuit 96 may also receive input signals, such as clock signals, synchronizing signals, and bias signals, from other devices. Although sensor array 90 and circuit 96 are shown as separate elements, it is possible to integrate the two elements into a single integrated device. Furthermore, it is possible to integrate sensor array 90 with a processor or other device.

As seen in Figure 7, the present invention comprises a scanning system generally indicated by reference number 118. Scanning system 118 comprises sensor arrays 110,

processor 112, transport device 114, and magnet 116. Sensor arrays 110 may be any of the sensor arrays discussed previously that are adapted to meet the needs of the particular application. Although two arrays are shown, any number of arrays may be used depending on the application. Transport device 114 is provided to produce relative motion between a magnetic material bearing object 58 and sensor arrays 110. Magnet 116 is provided to magnetize magnetic material on object 58 so that the magnetic material produces detectable magnetic fields. The shape and orientation of magnet 116 may be altered and still achieve the objects of the invention. In addition, a greater number of magnets may be used. Sensor arrays 110 is operatively connected to processor 112. Processor 112 may be adapted to perform a number of functions that are related to the function of system 118. For example, processor 112 may analyze and store data transmitted from array 110. Tensioning devices 120 may also be provided for placing object 58 in a preferred position relative to sensors 110.

Scanning system 118 allows object 58 to be used as a read only memory device. In this embodiment magnetic material is deposited on object 58 in a predetermined two-dimensional pattern with predetermined densities. The pattern and densities of the magnetic material serves as a code that is capable of conveying information to processor 112. Because it is the pattern of the magnetic material that conveys information and not the polarity of the material, object 58 is capable of permanently storing data. As object 58 passes between magnet 116, the polarity of the magnetic material is adjusted to a predetermined orientation. Sensor array 110 is then able to read the two-dimensional pattern of the material.

Scanning system 118 may also comprise any number of other sensors and devices. For example, system 118 may comprise a photodiode array or charge couple device array 121, a photo transistor 122 with an opposing ultraviolet light source 123, and a photo diode 125 with an opposing infrared or visible light source 124. Any one of these sensors or a

combination of these sensors with other sensors may be used by system 118 to read additional data from object 58. For example, in currency validation photodiodes and a light source may be used to analyze certain patterns, materials, and structures on the currency.

One of the advantages of the present invention is that data or programs may be conveniently entered into processor 112. Object 58 may be a preprogrammed read only memory device that is inserted into system 118. As sensor arrays 110 read the data, processor 112 recognizes the data as data or programs to be added to the processor. Processor 112 then performs the necessary functions to either store the data or reprogram itself. In this way, an untrained operator may easily and efficiently reprogram or add data to system 118. This may be especially advantageous to currency validators that must be reprogrammed when new currencies are issued.

Another advantage of the present invention is that changes in currency do not require modifications of scanning system 118. Governments periodically change the properties of their currencies to hinder counterfeiting. If a system relies upon one-dimensional sensors, it may be necessary to reposition the sensors to obtain appropriate data. Since the present invention is capable of scanning the entire surface of a currency object, there is no need to modify the scanning array of the system to accept modified currencies. It is only necessary to update the standard data of the system. This may be done using object 58 as discussed above.

As seen in Figure 8, system 118 may comprise a processor 130 that is operatively connected to transport mechanism 114, sensor array 110, other sensor 148, memory 140, and analog to digital converter (ADC) or comparator 138. Processor 130 is capable of controlling the scanning process as well as performing other tasks associated with the scanning application. Processor 130 controls transport mechanism 114 so that object 58 and sensor array 110 move relative to each other at a predetermined rate. Transport mechanism 114 may

also be made to reject object 58. Processor 130 may communicate with sensor array 110, sensor 148, and ADC 138 to provide synchronization signals and other data.

As the sensor array scans data from object 134, it multiplexes the data and transmits the data to ADC 138. ADC 138 may convert the multiplexed data to serial eight bit data and transmits the data to memory device memory device 140, processor 130, or both. Process 130 and memory device 140 may be any of a large number of devices that are well known in the art. Alternate sensor 148 may be provided for scanning object 58 for a type of data not provided by sensor array 110. After scanning the data, the data may be transmitted to ADC 138 for conversion to serial eight bit data.

Analysis software and data 144 may be provided to processor 130 by erasable programmable read only memory (EPROM) 142. This allows analysis software 144 to be changed by switching EPROM 142 with another programmed EPROM. Many other methods and devices may also be used for introducing new software and data into system 118. For example, a communication network may be provided for loading software remotely or object 58 may be used as a read only memory as discussed above.

Analysis software may comprise a large number of methods that have been devised in the art for recognizing patterns and comparing features. For example, analysis software may comprise a very fast two-dimensional template-patching algorithm. This algorithm takes into account printing/plate tolerances and known irregularities. Templates may be based on known binary (black and white) patterns, such as the one shown in Figure 2B. Additionally, full eight bit gray level image information (not shown) may be used during the analysis procedure. System 118 may be used to analyze the entire surface of object 58 or, because it is capable of high resolution, small individual features of the object may be analyzed. Once the analysis is complete, system 118 may perform other appropriate tasks and functions.

Processor 146 may also be adapted to communicate with device 146. Device 146 may be any device that is relevant to the operation of system 118. For example, device 146 may be a display device, such as a monitor or printer, for displaying magnetic images. In the field of currency validation, it may be very useful to display a magnetic image of object 58. This may be particularly useful to closely examine known counterfeit currency.

It is recognized that some or all of the components and elements shown in Figure 8 may be integrated into a single embedded device. This may facilitate efficient manufacturing and maintenance.

SUMMARY

It may now be seen from the above specification that the present invention comprises a novel magnetoresistive sensor array and scanning system. The present invention comprises:

1. A magnetoresistive sensor array that is capable of efficiently scanning magnetic fields on at least a two-dimensional area of an object during a single movement by the object;
2. A system for collecting magnetic field data on a two-dimensional area of an object;
3. A system for analyzing magnetic field data on a two-dimensional area of an object;
4. A system that may be reprogrammed by scanning the pattern and intensities of magnetic fields on an object; and
5. A system for recognizing and validating currency objects.

While the above description contains numerous specificities, these should not be construed as limitations on the scope of the invention but rather as exemplifications of some of the presently preferred embodiments thereof. For example:

1. The number and type of magnetoresistive sensors comprising an array may be varied;
2. The shapes, sizes, and arrangements of the magnetoresistive sensors may be varied singly or in combination;
3. The number, shapes, sizes, and arrangements of the magnets can be varied singly or in combination; and
4. The shape, number, and configuration of the magnetic flux guides may be varied; and
5. The sampling rate of each sensor may be varied independently or in unison with other sensors in a scanning movement.

Thus, the scope of the invention should be determined by the appended claims and their legal equivalents rather than by the examples given.

CLAIMS

What is claimed is:

1. A sensor array for scanning magnetic fields on an object and producing output signals for generating two-dimensional data, comprising:

   (A) at least one substrate;

   (B) a plurality of adjacent magnetoresistive sensors attached to said substrate in close relative proximity, said sensors being adapted to produce variable output signals responsive to magnetic fields applied to said sensors, the signals being adapted to produce two-dimensional data of the magnetic fields on the object,

   wherein the sensor array is adapted to scan a two-dimensional area on the object in a single motion by the object.

2. The sensor array of claim 1 wherein said sensors are arranged in a substantially linear configuration on said substrate.

3. The sensor array of claim 1 wherein separation between said sensors is substantially ten microns or less.

4. The sensor array of claim 1 wherein linear density of said sensors is substantially at least one sensor per millimeter.

5. The sensor array of claim 1 further comprising a multiplexing circuit operatively connected to said sensors.

6. The sensor array of claim 1 wherein each said sensor comprises a first and second magnetoresistive element, said first element being adapted to receive a stronger magnetic field form the object than said second sensor, said first and second elements being operatively connected to provide a differential output signal.

7. The sensor array of claim 1 further comprising at least one magnetic flux guide.

8. The sensor array of claim 1 further comprising a processor operatively connected to said sensor array.

9. A sensor array for scanning magnetic fields on an object and producing output signals for generating two-dimensional data, the sensor array being adapted to scan an area of the object during a single pass by the object, the sensor array comprising:

(A) a plurality of sensor means for scanning a two-dimensional area of an object and producing variable output signals responsive to magnetic fields on the object; and

(B) means for holding said plurality of sensor means in a predetermined configuration relative to the object.

10. The sensor array of claim 9 further comprising means for multiplexing the output signals.

11. The sensor array of claim 10 further comprising means for guiding magnetic flux to said sensor means.

12. The sensor array of claim 9 further comprising means for processing the output signals produced by said sensor means.

13. The sensor array of claim 9 further comprising means for producing a differential output signal.

14. A system for scanning magnetic fields on an object and producing two-dimensional magnetic field data, comprising:

(A) at least one magnetoresistive sensor array, said sensor array being adapted to scan a two dimensional area of the object during a single motion past the object and generate variable output signals responsive to the magnetic fields on the object;

(B) at least one processor operatively connected to said sensor array, said processor being adapted to processes the output signals and generate two-dimensional magnetic field data.

15. The system of claim 14 further comprising a transport device for producing relative motion between said sensor array and the object.

16. The system of claim 15 wherein said processor is adapted to control said transport device.

17. The system of claim 14 wherein said processor is adapted to analyze the data.

18. The system of claim 14 further comprising at least one non-magnetoresistive sensor operatively connected to said processor, said electromagnetic sensor being adapted to scan the object and produce output signals.

19. The system of claim 14 wherein said processor is adapted to generate a two-

dimensional image of magnetic fields on the object.

20. The system of claim 14 further comprising a display device operatively connected to said processor.

21. The system of claim 14 further comprising a memory device.

22. The system of claim 14 wherein said system is adapted to read data or programs from the object, the data or programs being for the operation of the system.

23. A system for scanning magnetic fields on an object and producing two-dimensional magnetic field data, comprising:

(A) at least one sensor array means for scanning a two dimensional area of the object during a single motion past the object and generating variable output signals responsive to the magnetic fields on the object; and

(B) at least one processor means operatively connected to said sensor array for processing the output signals and generating two-dimensional magnetic field data.

24. The system of claim 23 further comprising means for storing the high-resolution data.

25. The system of claim 23 further comprising means for producing relative motion between said sensor array means and the object.

26. The system of claim 23 further comprising means for scanning non-magnetic data.

27. The system of claim 23 further comprising means for reading data or programs from the object, the data or programs being for operation of the system.

28. The system of claim 23 further comprising means for displaying a magnetic image.

29. A system for determining the authenticity of a currency object, the system comprising:

(A) at least one magnetoresistive sensor array, said sensor array being adapted to scan a two-dimensional area of the currency object in substantially a single motion past the object and generate variable output signals responsive to magnetic fields on the currency object;

(B) at least one memory device, said memory device being adapted to store two-dimensional magnetic data of a standard currency object; and

(C) at least one processor operatively connected to said sensor array and said memory data, said computer processor being adapted to compare the output signals with the magnetic data.

30. The system of claim 29 further comprising a transport device for producing relative motion between the currency object and said sensor array.

31. The system of claim 30 wherein said processor is adapted to control said transport device.

32. The system of claim 29 further comprising at least one non-magnetoresistive sensor operatively connected to said processor.

33. The system of claim 29 wherein the system is adapted to read data and programs from a programming object, wherein the data and programs are used in the operation of the

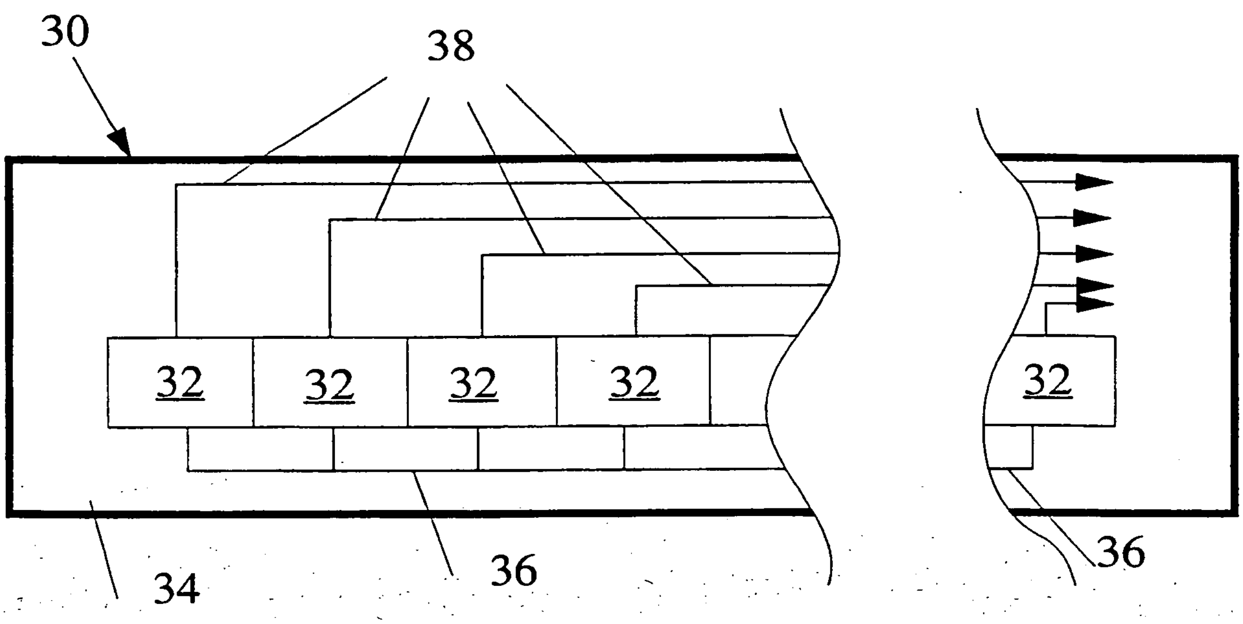

Fig. 3

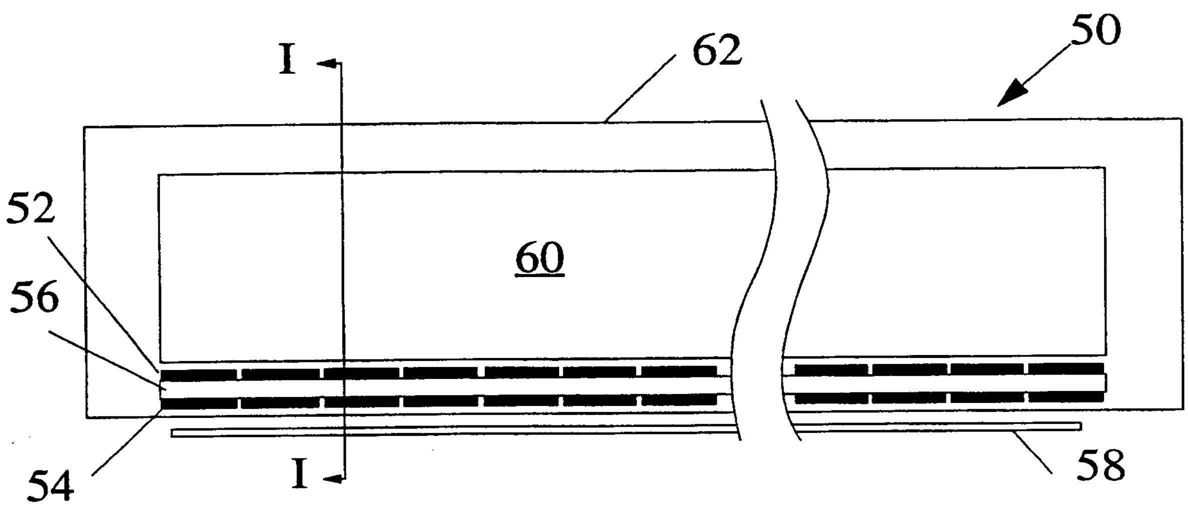

Fig. 4A

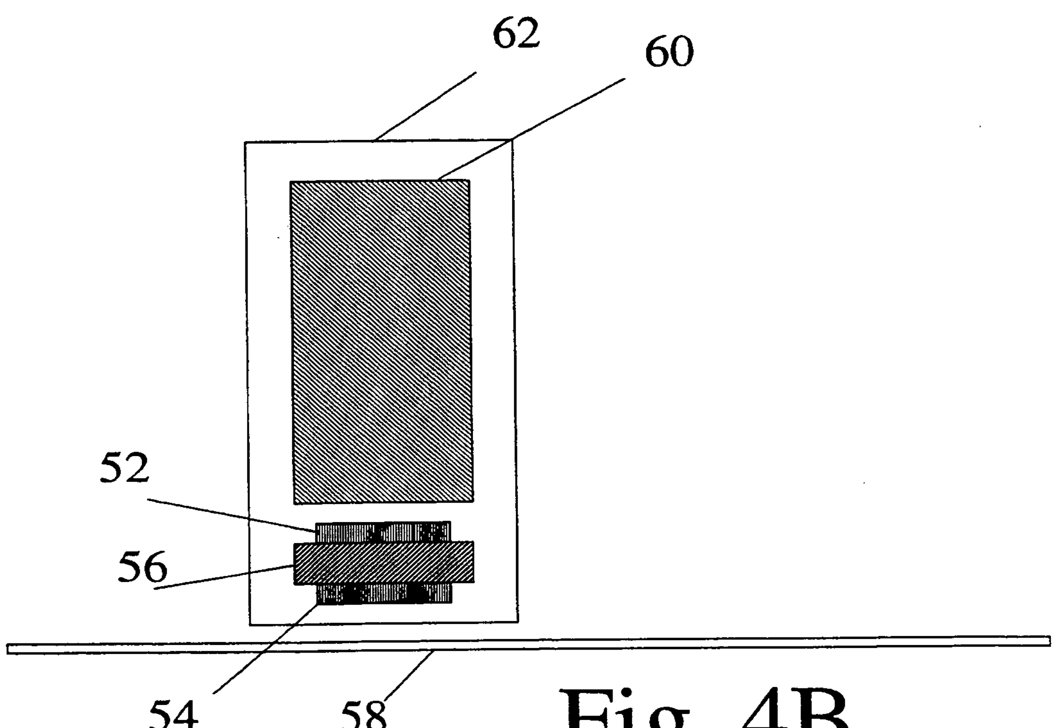

Fig. 4B

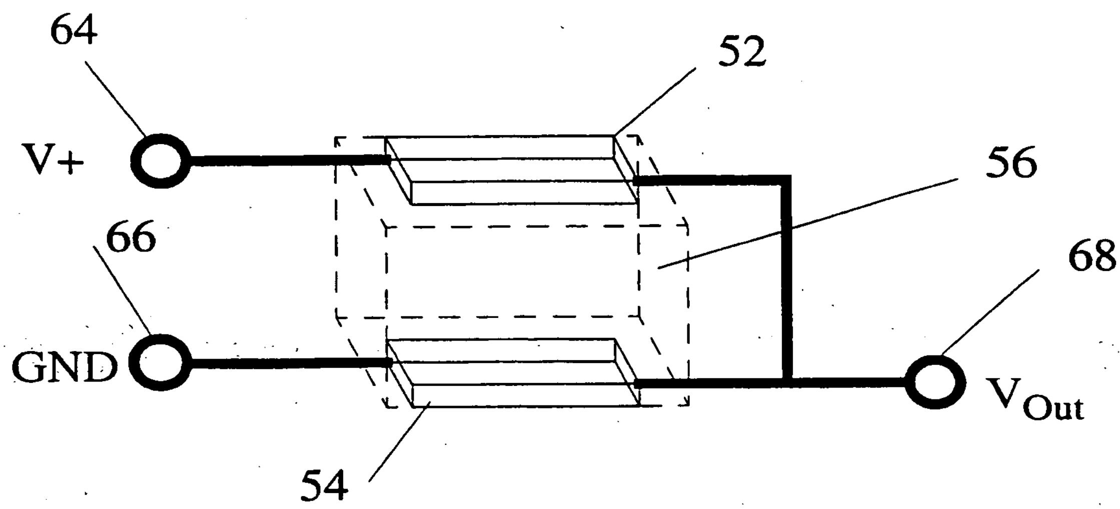

Fig. 4C

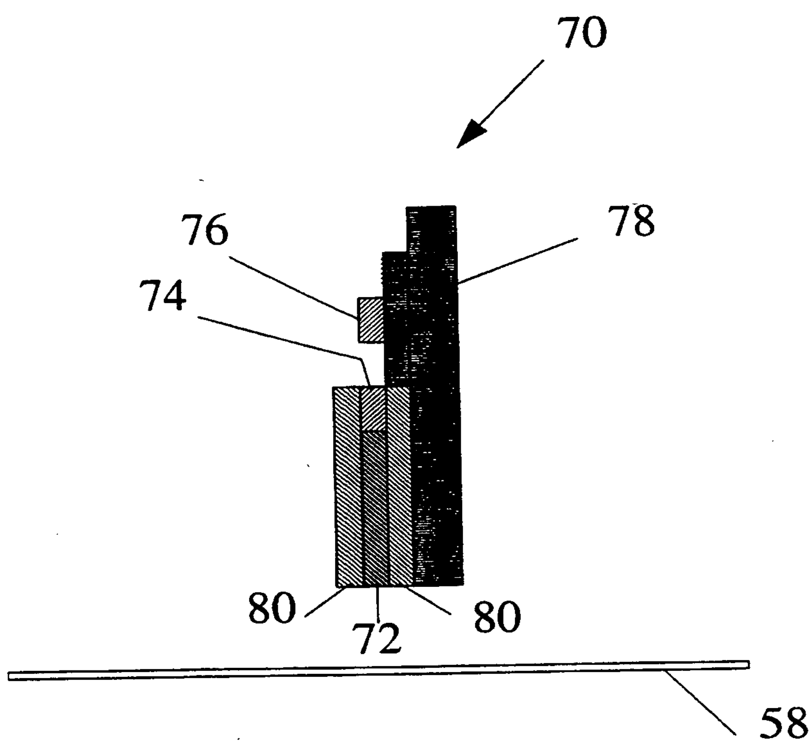

Fig. 5

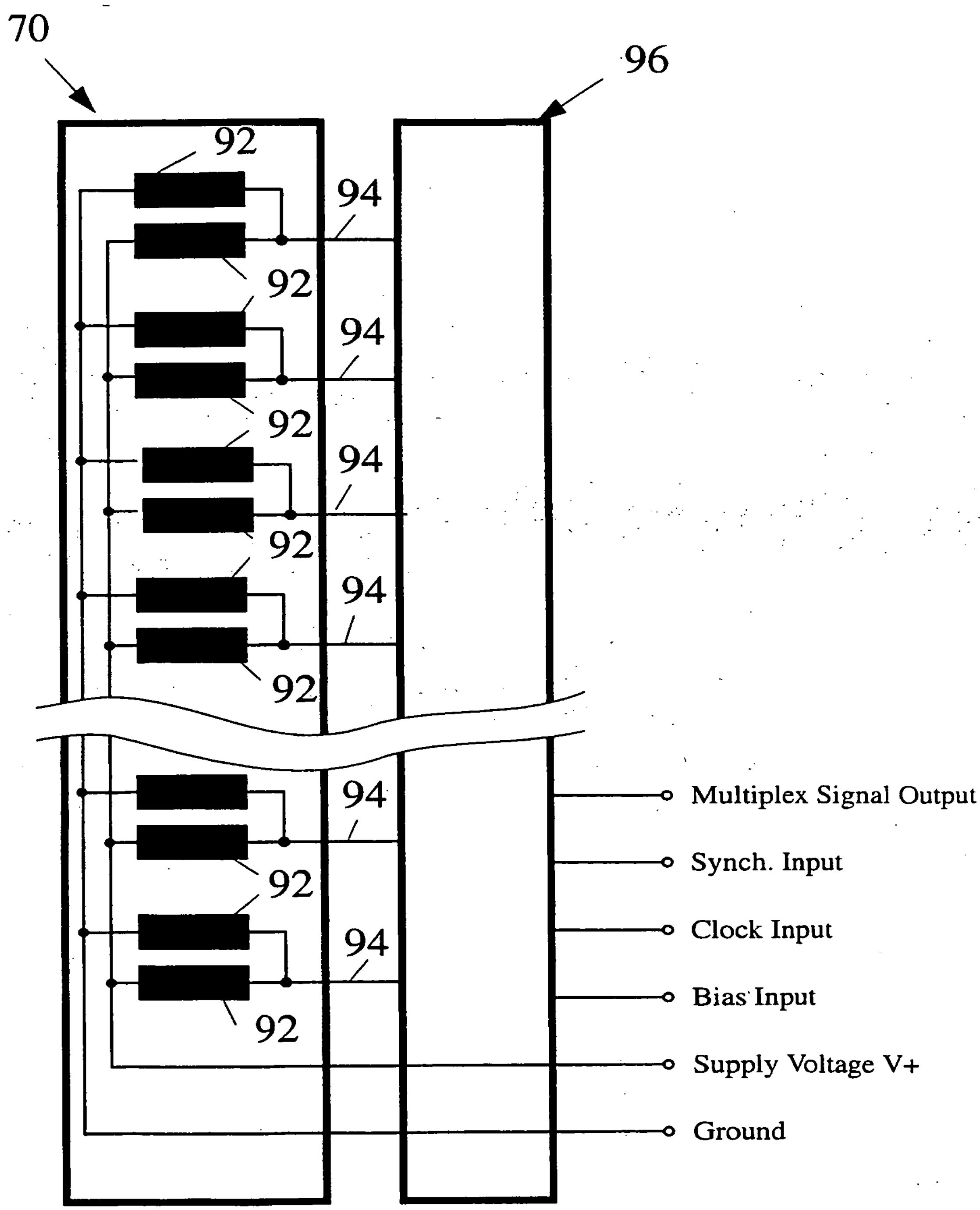
70
96
92
94
Multiplex Signal Output
Synch. Input
Clock Input
Bias Input
Supply Voltage V+
Ground

Fig. 6

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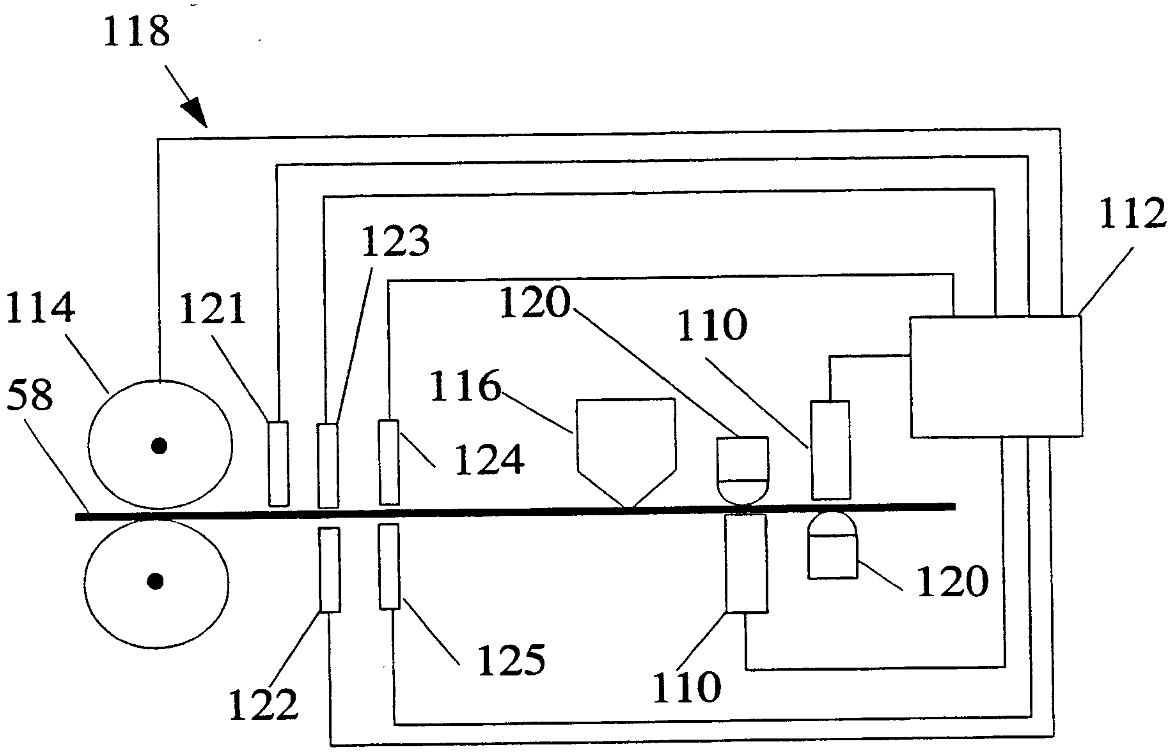
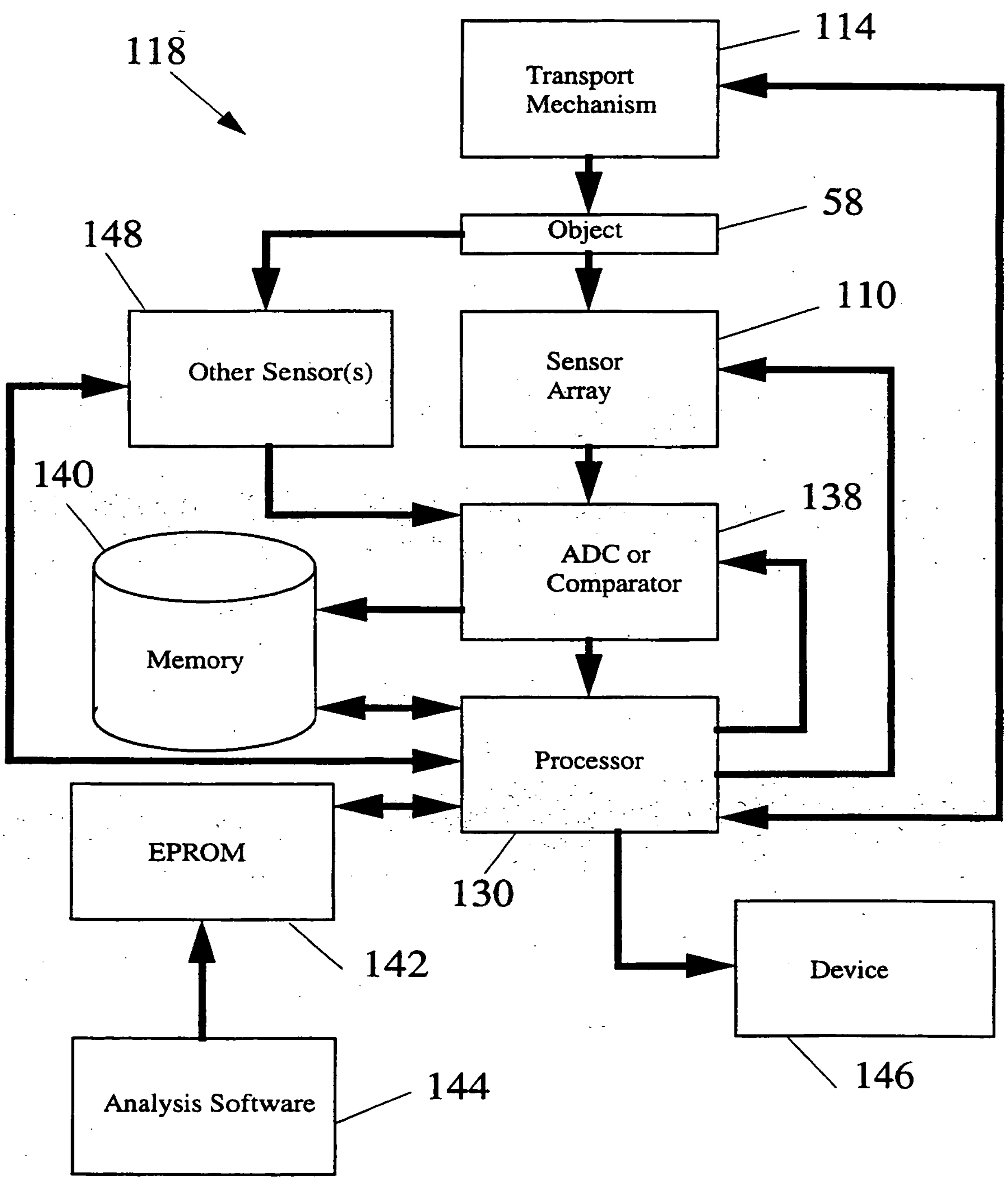


Fig. 7



118
Transport Mechanism
114
Object
58
148
Other Sensor(s)
Sensor Array
110
140
ADC or Comparator
138
Memory
Processor
EPROM
130
142
Device
Analysis Software
144
146

Fig. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/03989

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :H04N 1/19; G06K 1/28, 9/78
US CL :382/135, 320; 341/15
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 382/135, 320, 139, 140; 341/15; 324/207.21; 365/8; 360/113; 340/825.34; 235/449, 493

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Please See Extra Sheet.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,988,850 A (MASUDA et al.) 29 January 1991, entire patent.	1-33
Y	US 5,358,088 (BARNES et al.) 25 October 1994, abstract, col.2 line 40 to col.3 line 30, col.5 lines 1-59, col.9 lines 14-47.	1-33
Y	US 5,452,163 A (COFFEY et al.) 19 September 1995, entire patent.	1-33
Y	US 5,585,775 A (ISHISHITA) 17 December 1996, entire patent.	1-33
Y	US 4,973,851 A (LEE) 27 November 1990, abstract, col.3 line 39 to col.4 line 50.	26, 29-33
Y	US 5,495,929 A (BATALIANETS et al.) 05 March 1996, entire patent.	26, 29-33

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

- * Special categories of cited documents:
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- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 JULY 1998	12 AUG 1998

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	SO et al. Magnetic Domain Imaging in Coated Silicon-Iron using Magnetoresistive Sensors. IEEE Transactions on Magnetics. 18 April 1995, Vol.31. No.06. pages 3370-3372	1-33
Y	EP 342062 A (FUJITSU LIMITED) 15 November 1989, entire document.	1-33
Y	JP 03-179214 A (FUJITSU) 05 August 1991, page 3, left col., line 4 - line 19, figure 1 - figure 3.	5, 8, 10, 14-22, 27, 29-33
Y	JP 04-098592 A (FUJITSU) 31 March 1992, page 1, left col., line 4 - right col., line 9, figure 1	18, 27
A	OKABE et al. Grooved Bar-Code Pattern Recognition System with Magnetoresistive Sensor. IEEE Transactions on Magnetics. 17 April 1990. Vol.26. No.05. pages 1575-1577	1-33

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/03989

B. FIELDS SEARCHED
Electronic data bases consulted (Name of data base and where practicable terms used):

APS, INSPEC, WPIDS
search terms: magnetoresistive, sensor, detector, array, scan, high density, high resolution, two dimensional, authenticate, validate